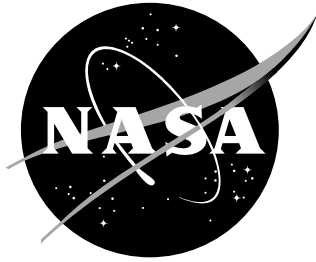


NASA/TM-2000-209840



On-Line Database of Vibration-Based Damage Detection Experiments

Richard S. Pappa
Langley Research Center, Hampton, Virginia

Scott W. Doebling
Los Alamos National Laboratory, Los Alamos, New Mexico

Tina D. Kholwad
University of New Mexico, Albuquerque, New Mexico

January 2000

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

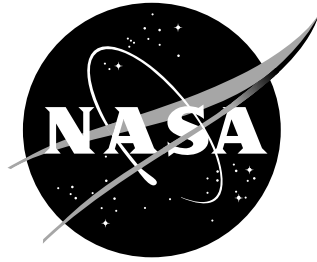
- **TECHNICAL PUBLICATION.** Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers, but having less stringent limitations on manuscript length and extent of graphic presentations.
- **TECHNICAL MEMORANDUM.** Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- **CONTRACTOR REPORT.** Scientific and technical findings by NASA-sponsored contractors and grantees.
- **CONFERENCE PUBLICATION.** Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.
- **SPECIAL PUBLICATION.** Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.
- **TECHNICAL TRANSLATION.** English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at <http://www.sti.nasa.gov>
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA STI Help Desk at (301) 621-0134
- Phone the NASA STI Help Desk at (301) 621-0390
- Write to:
NASA STI Help Desk
NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320

NASA/TM-2000-209840



On-Line Database of Vibration-Based Damage Detection Experiments

Richard S. Pappa
Langley Research Center, Hampton, Virginia

Scott W. Doebling
Los Alamos National Laboratory, Los Alamos, New Mexico

Tina D. Kholwad
University of New Mexico, Albuquerque, New Mexico

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

January 2000

Available from:

NASA Center for AeroSpace Information (CASI)
7121 Standard Drive
Hanover, MD 21076-1320
(301) 621-0390

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161-2171
(703) 605-6000

On-Line Database of Vibration-Based Damage Detection Experiments

Richard S. Pappa

Structural Dynamics Branch
NASA Langley Research Center
Hampton, VA 23681
E-mail: r.s.pappa@larc.nasa.gov

Scott W. Doebling

Engineering Analysis Group
Los Alamos National Laboratory
Los Alamos, NM 87545
E-mail: doebling@lanl.gov

Tina D. Kholwad

Co-op Student at NASA LaRC
University of New Mexico
Albuquerque, NM 87131
E-mail: tinakhol@unm.edu

ABSTRACT

This paper describes a new, on-line bibliographic database of vibration-based damage detection experiments. Publications in the database discuss experiments conducted on actual structures as well as those conducted with simulated data. The database can be searched and sorted in many ways, and it provides photographs of test structures when available. It currently contains 100 publications, which is estimated to be about 5%-10% of the number of papers written to date on this subject. Additional entries are forthcoming. This database is available for public use on the Internet at the following address: <http://sdbpappa-mac.larc.nasa.gov>. Click on the link named "dd_experiments.fp3" and then type "guest" as the password. No user name is required.

INTRODUCTION

Detection of structural damage using changes in vibration characteristics has received considerable research attention in recent years. This subject is part of a broader area of research and development known by various names including "structural health monitoring," "system health maintenance," and "integrated vehicle health management" [1,2]. Assessing structural integrity using vibration data has broad, potential application throughout the aerospace, civil, and mechanical engineering fields [3]. Researchers have proposed numerous ways to detect damage with vibration data (for example, by monitoring modal parameters [4,5]), but many unanswered questions remain concerning the effectiveness and usefulness of this technology.

The authors have created a new, on-line bibliographic database of vibration-based damage detection experiments to help answer the following three questions:

1. What types of experiments have been conducted to date to prove or disprove various methods?
2. Do methods that work on simple, laboratory structures also work on real, fully assembled structures?
3. Where do we go from here to move this technology to a state of readiness where it can be integrated into future structural designs?

The database is available to anyone with Internet access and a standard Web browser.

This paper explains how to access and use the database and gives an overview of its contents. To date, 100 publications have been tabulated. This number is expected to grow to over 1000 in the months ahead. Readers are encouraged to submit citations of additional publications they have written for inclusion in this public database. If possible, also send electronic photographs of the test structures used in the experiments. Submit this information by e-mail to: r.s.pappa@larc.nasa.gov.

The database uses commercial, off-the-shelf software known as FileMaker Pro [6,7]. Use of this particular brand of software is not an official endorsement or promotion of this product by the authors or the United States Government.

LOGGING IN AND GETTING HELP

To access the database, point your Web browser at the following address: <http://sdbpappa-mac.larc.nasa.gov>. You do not need FileMaker Pro software installed on your computer to use the database, including its searching and sorting capabilities. Figure 1 shows the welcome screen that will appear. Enter the database by clicking the link

named “dd_experiments.fp3” and then type “guest” as the password. No user name is required.

Help is available at any time by clicking the “?” icon located at the top of each page. This help information is a built-in feature of FileMaker Pro Web Companion, the Web publishing component of the FileMaker Pro software. The help text mentions that you may be able to edit, create, or delete records. You will not be able to perform these functions when you access the database using the “guest” password. When you are finished reading the help text, delete this window in your Web browser to return to the database.

TABLE VIEW

Figure 2 shows the initial database screen. This image was captured on a computer monitor with a resolution of 1024 x 768 pixels, which is the minimum resolution required to see the entire horizontal dimension of the table without scrolling. Use the vertical scroll bar to see additional rows of the table below the tenth record. (Each record in the database corresponds to one publication.) By default, you are viewing records 1 through 25, which is indicated in the “Record range” box to the upper-left of the table. To see all available records, change the “25” in the box to a large number and press Enter or click the small arrow icon adjacent to the box. You can now move through the entire database using the vertical scroll bar. There are several other ways to select the range of record numbers for viewing, which are explained in the help text.

Each record in the database has many fields of information associated with it. You are currently viewing the data in the “Table View” mode, where you see only five of these fields (Author & Date Code, Affiliation, Title, Test Structure, and Simulated Structure). These five fields were selected during database development to provide a sufficient, succinct summary of each record in a table format. All of the fields are self-explanatory except the Author & Date Code field, which contains the first author’s last name appended with the year of publication and a counter index. For example, the Author & Date Code of “Kim, H. M. 1995-2” indicates that this is the second paper entered into the database that was written in 1995 by H. M. Kim.

Notice the “(P)” appearing at the end of the Test Structure field in the first record of the database (the Author & Date Code of the first record is “Abdalla, M. 1997-1”). This “(P)” indicates that a photograph of the test structure is

available for viewing. You can see the photograph and additional information associated with the first data record by shifting to the “Form View” mode, discussed next.

FORM VIEW

Form View provides a more detailed look of each record in the database individually. To see the first record in Form View, do one of the following things:

- Click the “Form View” tab at the top of the window
- or
- Click the small numeral “1” to the left of the first row in the table.

Figure 3 shows the first record in Form View mode. You will probably need to use the vertical scroll bar to see the entire contents of this record. Form View displays ten fields of information associated with each record (Author & Date Code, Affiliation, Citation, Test Structure, Simulated Structure, Methodology, Photograph, Photograph Name, Date Added to Database, and Date of Last Modification). These ten fields were selected during database development to provide a useful, succinct description of each record in a list format. All of the fields are self-explanatory except the Methodology field, which contains a paraphrase of the specific vibration-based method used by the authors to detect structural damage in their experiment.

You can move to other data records in several ways. To go directly to a specific record number, type the number in the “Record” box and press Enter or click the small arrow icon adjacent to the box. To see the previous or next record, click the upper or lower page, respectively, of the small book icon. You can also skip several records at a time by sliding the tab located on the right edge of the book icon either up or down.

You may notice the same photograph appearing in more than one record of the database. To conserve disk space, each photograph is stored only once in a separate database file named “photos.fp3.” The photographs in this second file are then dynamically linked to the Photograph field in the first file using the Photograph Name field as a key. The interested reader is welcome to examine the photograph database also. Access it by pressing the Home icon located at the top of each page (to the right to the “?”

icon) and then click the link named “photos.fp3.” Return to the publications database when you are finished by pressing the Home icon again and then click the link named “dd_experiments.fp3”

SEARCHING THE DATABASE

Search the database to locate specific information of interest by clicking the “Search” tab located next to the Form View tab at the top of the window. You may begin in either the Table View or Form View mode. Following the search, the records satisfying your search criteria are displayed in Table View format.

Figure 4 shows the search specification page that appears when you click the “Search” tab. To begin, choose either AND or OR logic using the radio buttons at the top of the page. Most searches use AND logic, and this is the default value. Next, enter various words, phrases, dates, or other information of interest in the appropriate blank boxes. Please click the “?” at the top of the page for a full explanation of various search options and operators that are available. When you are finished reading the help text, delete this window in your Web browser to return to the database. For each search criteria you enter, select the type of search to be conducted in the pull-down menu located in each row. There are two choices for each field: “contains” the criteria or “does not contain” the criteria. Finally, begin the search by clicking the “Start search” button located at the top-left of the window.

A typical search result appears in Figure 5. This table shows all of the records in the database containing the phrase “Los Alamos” in the Affiliation field. If you switch to the Form View mode at this point, you will be working with only these eight records resulting from the search, rather than with the entire set of 100 records contained in the database. You can examine each of the eight records individually in Form View mode by clicking the upper or lower page of the small book icon to go to the previous or next record, respectively. You can return to working with the complete set of records in the database at any time by pressing the “Find all” button.

SORTING THE DATABASE

The records in the database can also be sorted in various ways to help locate specific data more quickly. By default, the database is sorted in ascending order of the Author & Date Code field. Sort the database in other ways by clicking the “Sort” button located in the top-left area

of the window in both the Table View and Form View modes. Following the sorting operation, the sorted records are displayed in Table View format.

Figure 6 shows the sort specification page that appears when you click the “Sort” button. You can sort the contents of the database by choosing up to four field names and whether each field is to be sorted in ascending or descending order. Sorting is performed based on the first field, then the second field, etc. After selecting the field names and sorting directions, begin sorting by clicking the “Start sort” button at the top-left of the window.

Figure 7 shows typical results of a sorting operation, conducted by sorting the Title field of each record in ascending order. This sort was performed immediately after obtaining the search results shown in Figure 5, so only the eight records with “Los Alamos” in the Affiliation field are still being displayed. If you click the “Find all” button at this point, you will see all 100 records in the database sorted in ascending order of the Title field. (In other words, the “Find all” button cancels the last search operation but does not cancel the last sort operation.) You can specify a different sorting order if you wish by clicking the “Sort” button again and making other selections. To deactivate sorting, you must perform another sorting operation with no fields of information selected.

CONCLUSIONS

This paper discussed an implementation of one of the newest capabilities available on the World Wide Web, the searchable and sortable technical database. This bibliographic database of vibration-based damage detection experiments can be used by anyone having Internet access and a standard Web browser. Users can search and sort the database in a variety of ways, and the results of their requests are displayed on dynamically changing Web pages. The database currently contains 100 publications, which is estimated to be about 5%-10% of the number of papers written to date on this subject. Additional entries and capabilities will be added to the database in the months ahead.

Readers are encouraged to submit citations of other publications they have written for inclusion in this public database. If possible, also send electronic photographs of the test structures used in the experiments. Submit this information by e-mail to: r.s.pappa@larc.nasa.gov.

ACKNOWLEDGEMENTS

Thanks to everyone who contributed lists of publications or photographs for this on-line database.

REFERENCES

- [1] Melvin, L. et al., "Integrated Vehicle Health Monitoring (IVHM) for Aerospace Vehicles," *Proceedings of the 1st International Workshop on Structural Health Monitoring*, Stanford University, Sept. 1997, pp. 705-714.
- [2] Chang, F.-K. (editor), *Proceedings of the 2nd International Workshop on Structural Health Monitoring*, Stanford University, Sept. 1999.
- [3] Doebling, S. W., Farrar, C. R., Prime, M. B., and Shevitz, D. W., "Damage Identification and Health Monitoring of Structural and Mechanical Systems from Changes in Their Vibration Characteristics: A Literature Review," Los Alamos Report LA-13070-MS, May 1996.
- [4] Hunt, D. L. et al., "Development and Implementation of a Shuttle Modal Inspection System," *Sound and Vibration*, August 1990, pp. 34-42.
- [5] Farrar, C. R. and Doebling, S. W., "An Overview of Modal-Based Damage Identification Methods," *EUROMECH 365 International Workshop: DAMAS 97, Structural Damage Assessment Using Advanced Signal Processing Procedures*, Sheffield, U.K., June 1997.
- [6] Langer, M., *Database Publishing with FileMaker Pro on the Web*, Peachpit Press, Berkeley, CA, 1998.
- [7] Feiler, J., *FileMaker Pro 4 and the World Wide Web*, Academic Press, San Diego, CA, 1999.



Figure 1 – Welcome Screen

	Author & Date Code	Affiliation	Title	Test Structure	Simulated Structure
1	Abdalla, M. 1997-1	University of Kentucky	Enhanced Damage Detection Using Alternating Properties	SASIA L&C X-Ray Truss (P)	4-DOF Box Model
2	Abdalla, M. 1998-1	University of Kentucky	Enhanced Damage Detection Using Linear Matrix Inequalities		12-DOF Box Model
3	Abdelghani, M. 1997-1	IFISA (France)	In-Operation Damage Monitoring and Diagnosis of Welding Structures, with Applications to Offshore Structures and Rotating Machinery	Supporting Steel Frame with Added Masses	
4	Abe, M. 1996-1	University of Tokyo (Japan)	Structural Damage Detection by Natural Frequencies		18-DOF Model
5	Al-Qaisi, A. 1997-1	University of Baghdad (Iraq)	Crack Detection in Plates by Sensitivity Analysis		Cracked Steel Plates
6	Allen, B. 1997-1	State College University	Vibration-Based Fault Detection of a Prop Aircraft Structure	Aluminum Plate, P-15 Wing Segment	
7	Banks, H. T. 1994-1	North Carolina State University	Distributed Parameter System Models for Damage Detection and Location in Beam Material Structures		Composite Beam with Piezoelectric (PZT) Patches
8	Beck, J. L. 1996-1	CalTech	Structural Health Monitoring Using Ambient Vibrations	11 Story Building	
9	Bowen, R. M. 1997-1	Orbital Sciences Corporation	Qualitative Versus Quantitative Structural Damage Evaluation Techniques for Composites	Thermosetting Resin Matrix Composites	
10	Cao, T. T. 1997-1	SASIA LLC & University of Kentucky	Application of Load Dependent Ritz Vectors in Structural Damage Detection		12-DOF Truss

Figure 2 – Initial Database Screen (Table View)

Form View - dd_experiments.fp3 - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location: http://sdbpappa-mac.larc.nasa.gov/FMRes/FMPro?db=dd%5fexperiments.fp3&format=formvw.htm&lay=form%5fweb&max=1&t


Table View

Form View

Search

?

Home



Record:

Total records: 100
Unsorted

Sort...

Find all

Database: dd_experiments.fp3

Viewing record 1 of 100

Author & Date Code

Abdalla, M. 1997-1

Affiliation

University of Houston

Citation

Abdalla, M., Grigoriadis, K. M., and Zimmerman, D. C., "Enhanced Damage Detection Using Alternating Projections," Proceedings of the 15th IMAC, Feb. 1997, pp. 1325-1331.

Test Structure

NASA LaRC 8-Bay Truss (P)

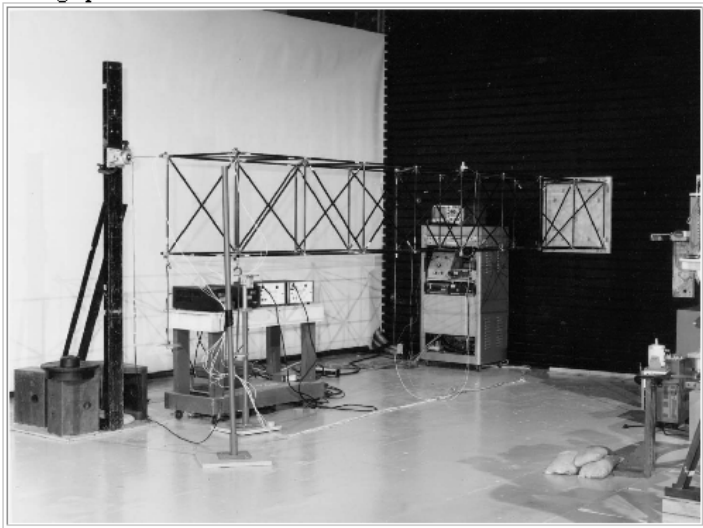
Simulated Structure

4-DOF Bar Model

Methodology

Identified damage-affected DOFs of the stiffness matrix using directional alternating projections with symmetry, sparsity, positive definiteness, and eigen-equation constraints.

Photograph



Photograph Name

NASA LaRC 8-Bay Truss

Date Added to Database

7/12/99

Date of Last Modification

9/20/99

Applet FMControlPanel running

Figure 3 – Typical Record (Form View)

Search - dl_experiments.lp3 - Netscape

File Edit View Go Communicator Help

Table View Form View Search 7

Total records: 100
Unsorted

Start search
Clear Fields

Database: dl_experiments.lp3

Select search type, enter search criteria, then click Start search Search type

☐ Match all words on page (AND) ☐ Match any word on page (OR)

Field	Type	Criteria
Author & Date Code	contains	
Author	contains	
Year of Publication	contains	
Affiliation	contains	
Title	contains	
Citation	contains	
Test Structure	contains	
Simulated Structure	contains	
Methodology	contains	
Photograph Name	contains	
Date Added to Database	contains	
Date of Last Modification	contains	
Accession No.	contains	

4 Top

Document Done

Figure 4 – Search Specification Page

Table View - dl_experiments.lp3 - Netscape

File Edit View Go Communicator Help

Table View Form View Search 7

Database: dl_experiments.lp3

Showing record range 1-8 of 8

Record range: 1-8

Total records: 100
Search result: 8
Unsorted
Sort...
Find all

	Author & Date Code	Affiliation	Title	Test Structure	Simulated Structure
1	Coward, P. J. 1997-1	Rensselaer Institute of Technology & Los Alamos	Application of the Stress Energy Damage Detection Method to Plate-Like Structures		Plated Plated Plate
2	Coward, P. J. 1998-1	Rensselaer Institute of Technology & Los Alamos	Comparative Study of Flexion Based Damage ID Algorithms	Beam (F), Plate	
3	Darkling, S. W. 1997-1	Los Alamos, Santa Catalina Pass, University of Colorado	Improved Damage Location Accuracy Using Stress Energy-Based Mode Selection Criteria	1-Bay Truss	
4	Darkling, S. W. 1997-2	Los Alamos, University of Colorado	Effects of Measurement Statistics on the Detection of Damage in the Alamos Canyon Bridge	Alamos Canyon Bridge (F)	
5	Duffy, T. A. 1998-1	Combining Engineers & Los Alamos	Damage Detection for Applications Undergoing Acid (Membrane) Response		1-DOF Model
6	Ferns, C. R. 1996-1	Los Alamos & University of Texas	Damage Detection Algorithms Applied to Experimental Modal Data From the 1-40 Bridge	1-40 Bridge (F)	1-40 Bridge
7	Ferns, C. R. 1996-2	Los Alamos & University of Texas	Comparative Study of Damage Identification Algorithms Applied to a Bridge 1 Experiment	1-40 Bridge (F)	
8	Robinson, H. A. 1996-1	University of Colorado, Santa, Los Alamos	Damage Detection in Aircraft Structures Using Dynamically Measured State Flexibility Matrices	DC-8 Fuselage	

Figure 5 – Typical Search Results (Affiliation = “Los Alamos”)

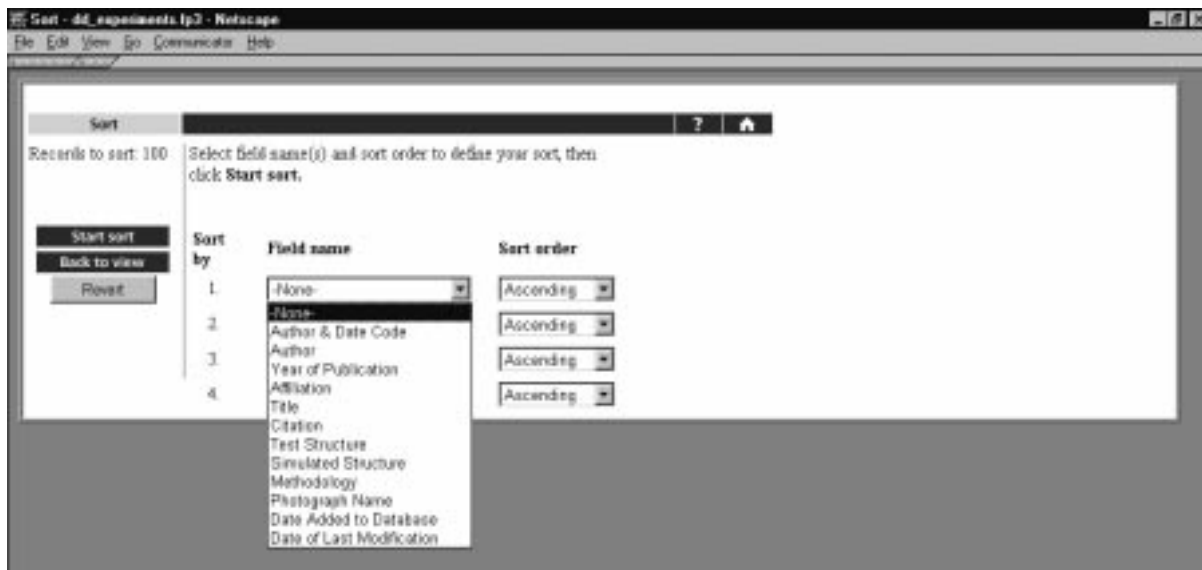


Figure 6 – Sort Specification Page

Table View - del_experiments.fp3 - Netscape

Database: del_experiments.fp3

Viewing record range 1-8 of 9

	Author & Date Code	Affiliation	Title	Test Structure	Simulated Structure
1	Concevi, P. J. 1997-1	Rose-Hulman Institute of Technology & Los Alamos	Application of the Strain Energy Damage Detection Method to Plate-Like Structures		Peened-Peened Plate
2	Fama, C. R. 1998-1	Los Alamos & University of Texas	Comparative Study of Damage Identification Algorithms Applied to a Bridge I. Experiment	L-40 Bridge (F)	
3	Concevi, P. J. 1999-1	Rose-Hulman Institute of Technology & Los Alamos	Comparative Study of Flexion-Based Damage ID Algorithms	Beam (F), Plate	
4	Fama, C. R. 1998-1	Los Alamos & University of Texas	Damage Detection Algorithms Applied to Experimental Model Data From the L-40 Bridge	L-40 Bridge (F)	L-40 Bridge
5	Duffy, T. A. 1998-1	Consulting Engineers & Los Alamos	Damage Detection for Applications Undergoing Axial (Monotonic) Response		S-DOP Model
6	Polkman, R. A. 1998-1	University of Colorado, Boulder, Los Alamos	Damage Detection in Aircraft Structures Using Dynamically Measured State Flexibility Matrices	DC-9 Fuselage	
7	Dowling, S. W. 1997-2	Los Alamos, University of Colorado	Effects of Measurement Statistics on the Detection of Damage in the Alamos Canyon Bridge	Alamos Canyon Bridge (F)	
8	Dowling, S. W. 1997-1	Los Alamos, Ecole Centrale Paris, University of Colorado	Improved Damage Location Accuracy Using Strain Energy-Based Mode Selection Criteria	S-Box Truss	

Figure 7 – Typical Sorted Results (Figure 5 Sorted by Title)

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE January 2000		3. REPORT TYPE AND DATES COVERED Technical Memorandum
4. TITLE AND SUBTITLE On-Line Database of Vibration-Based Damage Detection Experiments			5. FUNDING NUMBERS 706-12-21-02	
6. AUTHOR(S) Richard S. Pappa, Scott W. Doebling, and Tina D. Kholwad				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) NASA Langley Research Center Hampton, VA 23681-2199			8. PERFORMING ORGANIZATION REPORT NUMBER L-17930	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001			10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA/TM-2000-209840	
11. SUPPLEMENTARY NOTES Pappa: Langley Research Center, Hampton, VA; Doebling: Los Alamos National Laboratory, Los Alamos, NM; Kholwad: University of New Mexico, Albuquerque, NM. Presented at the 18th International Modal Analysis Conference, San Antonio, Texas, February 7-10, 2000.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified-Unlimited Subject Category 39 Distribution: Standard Availability: NASA CASI (301) 621-0390			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This paper describes a new, on-line bibliographic database of vibration-based damage detection experiments. Publications in the database discuss experiments conducted on actual structures as well as those conducted with simulated data. The database can be searched and sorted in many ways, and it provides photographs of test structures when available. It currently contains 100 publications, which is estimated to be about 5%-10% of the number of papers written to date on this subject. Additional entries are forthcoming. This database is available for public use on the Internet at the following address: http://sdbpappa-mac.larc.nasa.gov . Click on the link named "dd_experiments.fp3" and then type "guest" as the password. No user name is required.				
14. SUBJECT TERMS Vibration-Based Damage Detection, Damage Identification, Structural Health Monitoring, Structural Dynamics, Vibration Testing, Internet Databases			15. NUMBER OF PAGES 12	
			16. PRICE CODE A03	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	